Cracking the code to soot formation

Scientists unlock mystery to help reduce hazardous emissions

By Michael Padilla

The longstanding mystery of soot formation, which combustion scientists have been trying to explain for decades, appears finally solved, thanks to research led by Sandia.

Soot is ubiquitous and has large, detrimental effects on human health, agriculture, energy-consumption efficiency, climate and air quality. Responsible for significantly increased rates of cardiovascular and pulmonary diseases, soot also contributes to millions of deaths worldwide annually, largely from indoor cooking and heating in developing nations. It leads to tens of thousands of deaths in the U.S. every year, predominantly from anthropogenic emissions to the atmosphere, referred to as black carbon.

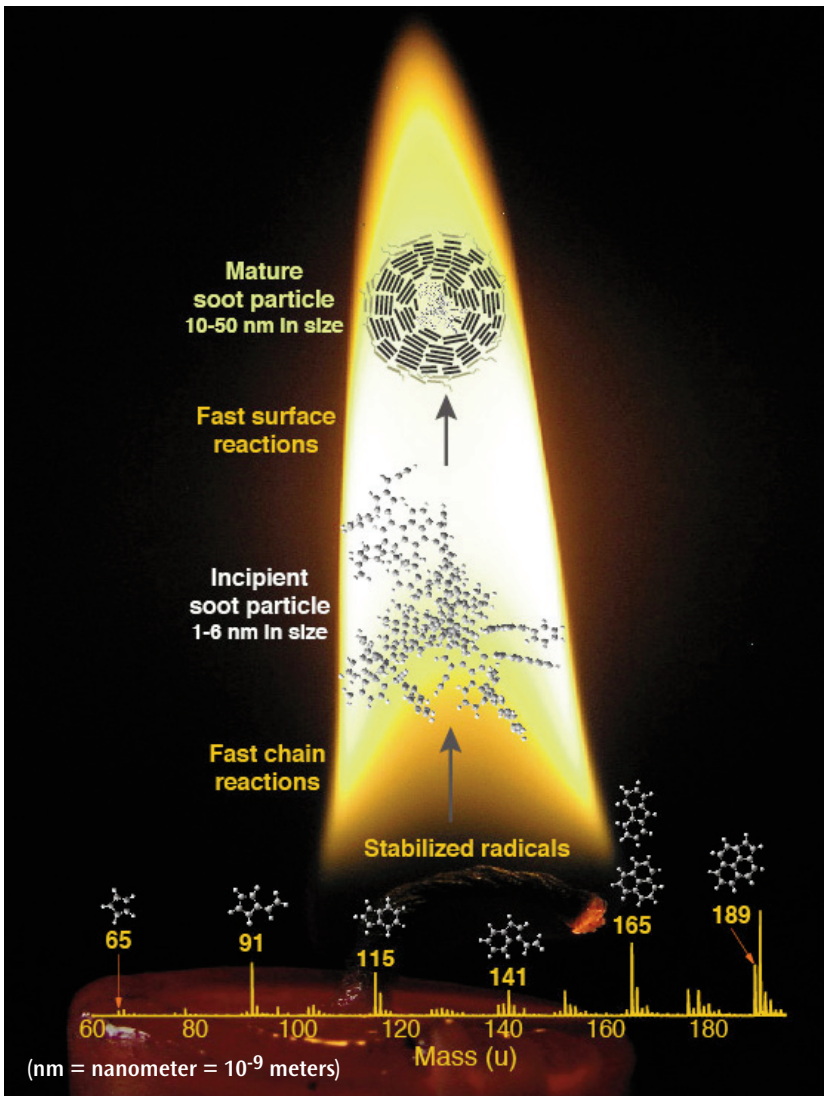
"By understanding soot formation, we have a better chance of being able to reduce its dangerous emissions from engines, forest fires and cook stoves and control its production and characteristics during industrial processes," said Sandia researcher Hope Michelsen, adding that everyone knows what soot is, but nobody has been able to explain how gaseous fuel molecules become soot particles.

She said soot formation turns out to be very different from the typical process of gas molecules condensing into a particle, instead requiring fast chemical reactions rather than condensation.

The solution also can apply to other high-temperature conditions, such as interstellar space, where large quantities of carbon-dust particles are formed, she said.

This groundbreaking work was published in a Science magazine paper, "Resonance-stabilized hydrocarbon-chain reactions may explain soot inception and growth." Authors include Hope, Olof Johansson and Paul Schrader from Sandia, and Kevin Wilson and Martin Head-Gordon from Lawrence Berkeley National Laboratory. Head-Gordon is also a chemistry professor at the University of California, Berkeley.

(Continued on page 4)



MYSTERY SOLVED — Scientists have discovered a mechanism for soot formation, solving a longstanding scientific mystery. In this image of a candle flame, the colors are from hot soot luminescence. The mass spectrum at the bottom shows the peaks for the radicals that drive reaction. The incipient soot particle shown between the two arrows is the cluster that marks a transition to the condensed phase. Fast reactions grow the particle shown at the top of the flame.

(Image courtesy of Hope Michelsen)

INSIDE . . .

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Sandia LabNews

Vol. 70, No. 18
Sept. 14, 2018

Managed by NTESS, LLC, for the National Nuclear Security Administration

Q&A with 2019 Truman Fellows

By Troy Rummler

MAGNET HUNTER — Pauli Kehayias has been invited to Sandia as a Truman Fellow to complete his research proposal, "Imaging microwave fields with sub-micron resolution using nitrogen-vacancy centers in diamond." (Photo courtesy of Pauli Kehayias)

Sandia will welcome two new Truman Fellows in October. Pauli Kehayias and Thomas O'Connor will join the Labs for the next three years to apply breakthroughs they have made in their respective fields to Sandia applications. They join six other Truman Fellows now conducting research at the Labs.

Lab News spoke to both incoming fellows about how they plan to fold their innovations into Sandia's R&D program.

Since 2004, Sandia's Harry S. Truman Fellowship in National Security Science and Engineering has sponsored high-risk, potentially high-value R&D through the Laboratory Directed Research and Development program. Candidates propose bold, cutting-edge research with a strong tie to Sandia's mission and must earn the endorsement of a selection committee of senior scientists, their future peers and Sandia's Chief Research Officer.

"Those who stay at Sandia after their three-year fellowships end become leaders of the next generation of Sandians," said Cindy Phillips, chair of the Truman

(Continued on page 4)

Business partnerships, technology transfer earn Sandia four regional awards

By Manette Newbold Fisher

TOP GLASS — Materials scientist Joey Carlson demonstrates the ease of casting an organic glass scintillator. Casting the low-cost scintillator, which could be used in radiation detectors, takes only a few minutes as compared to other scintillators that can take several months.

(Photo by Randy Wong)

Sandia has won four regional awards from the Federal Laboratory Consortium for its work to develop and commercialize innovative technologies.

The annual FLC awards program recognizes federal laboratories and their industry partners for outstanding technology transfer achievements.

"New technologies and partnerships continue to emerge from Sandia, showcasing the Labs' talented workforce and our impact in national security, emergency response and scientific modeling," said Jackie Kerby Moore, manager for Economic Development and the Labs' FLC representative.

The consortium's Mid-Continent and Far West regions recognized Sandia's achievements in four areas.

(Continued on page 7)

Lab News Notes: How to do science in retirement

Detecting quark nuggets, a candidate for extreme ball lightning and dark matter

By Pace VanDevender, Sandia retiree

Thirteen years ago, I was retiring early from a wonderful job as Sandia chief technology officer and vice president of science and technology to become an 18th century "gentleman (that means self-funded) physicist." I wanted to understand two mysteries before I died: puzzling electromagnetic signals observed on the Los Alamos-Sandia FORTE satellite and extreme ball lightning. The resulting adventure has had many twists and turns that led to dark matter and the first of five planned publications: Detection of Quark-nuggets—a candidate for dark matter.

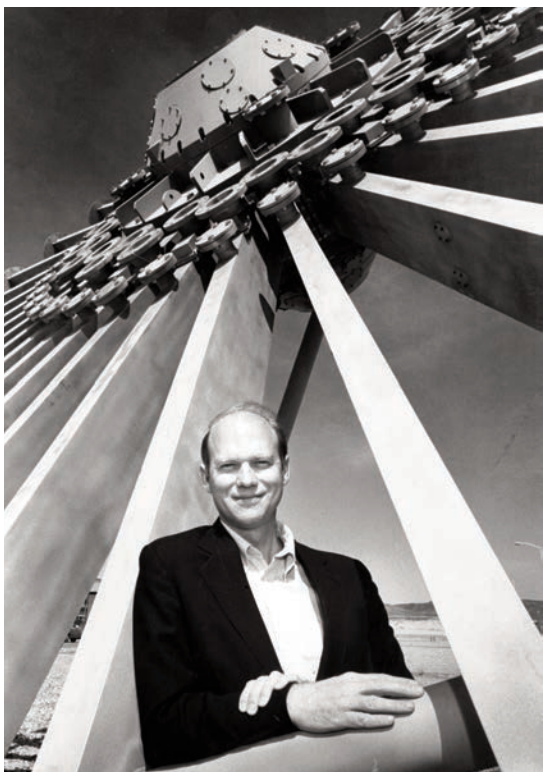
The FORTE signals were short-duration, narrow-band radio-frequency bursts captured in 1997, before FORTE's fully optimized triggering system prevented the detection of the annoying anomalies. The anomalies were soon forgotten until I found them while looking for a way to detect extreme ball lightning from space.

In contrast to weather-related, sub-second-duration ball lightning, extreme ball lightning occurs even in clear weather and lasts for 10 seconds to 20 minutes without a power source. Therefore, it is self-energized, but the power source is a mystery. My son Aaron and I investigated a 20-minute event in Ireland. The yield strength and electrical conductivity of the peat and the size of the deformations were consistent with the core of the extreme ball lightning, weighing about 1,000 tons, being more than 10,000 times more dense than gold, being magnetically levitated and rotating more than a million times per second!

After eliminating black holes (no magnetic field), naked singularities (unstable), the gravitational equivalent of an atom or GEA (insufficient magnetic field), we found quark nuggets were consistent with the observations. Quark nuggets are theoretical aggregations of strange up and down quarks (the building blocks of protons, neutrons and similar particles) in essentially even numbers.

AHOY, DARK MATTER — Pace VanDevender, former vice president for science and technology, poses with the expedition flag of the Explorer Club of New York City atop his original floating dark matter sensor, docked at the Great Salt Lake, Utah.

(Photo courtesy of Pace VanDevender)



STARBURST — VanDevender is shown in a 1992 file photo at the Starburst sculpture in Technical Area 4, which once was the power flow section of Particle Beam Fusion Accelerator I, and was removed when the accelerator was converted into the Saturn X-ray simulator.

(Lab News file photo)

We needed more data. From 2010 through 2012, I contracted with two digital signal processing engineers and a software specialist. We developed four very sophisticated, autonomous, special purpose electromagnetic sensors that could detect and time-synch electromagnetic pulses in an urban environment.

In 2012, we deployed the sensor array to Albuquerque, Atlanta, Denver and Bethesda in hopes of measuring FORTE-like signals from space and ball lightning signals from anywhere in the world. We got FORTE-like signals everywhere, but never on two sensors at once. Over the next two years, we showed the sources of the signals were within 100 meters of the antennae.

In 2015, I showed that quark nuggets would interact with matter through their immense magnetic field in the same way the earth interacts with the solar wind. That allowed me to calculate the energy deposition as a function of quark nugget mass so I could plan to detect them. Soon thereafter, I showed that the torque on the nuggets as they passed through the atmosphere would spin them to millions of revolutions per second. Their mass density, magnetic field and rotational velocity are just right for explaining the deformations from the ball lightning in Ireland and the FORTE signals. So quark nuggets became the sole hypothesis for both phenomena. I just had to detect them in as many ways as I could afford.

Fortunately, mentoring Sandians in the centers for military systems, radiation science and pulsed power provided the joy of working, through them, on Sandia's missions, as well as some supplementary income that funded the sensor suite and paid students for data analysis while they experienced real research. In addition, the New Mexico Small Business Assistance program funded Bob Schmitt to do the hydrodynamic simulations of a quark nugget impact — a vital contribution to our paper.

As explained in the paper, the most promising way to detect quark nuggets is to look for their impact in a very large and very quiet lake. So we constructed and now operate three sophisticated sensors in the Great Salt Lake, Utah, looking for dark matter impacts. The lake is a very hostile place for electronics and metals. The first system lasted four days, and the first platform lasted three months. Continual improvements have increased the lifetime of the electronics to a year and the lifetime of the platforms to at least 30 years. We are now calibrating the system with explosions throughout the lake to simulate quark nugget impacts. Then we can observe.

For future Gentleman Scientists or Engineers, some of the lessons I learned might be useful: 1) Build a team with the diverse expertise needed. Fortunately, the internet connects everyone, and finding interested people is not so hard. Our team members resided all over the U.S., the United Kingdom and the Republic of Ireland. 2) Include someone specifically tasked to be super critical and keep the team from believing its own constructs. Be thankful for them. In addition to my son Aaron, my friend and former boss Bill Brinkman (former Sandia and Bell Labs vice president and director of the DOE Office of Science) fulfilled that role wonderfully. I recall that they independently asked, "where is the physics in this draft paper?"

Contact me at pace@vandevender.com for more lessons learned, to get students to assist you, or to mentor students through the Student Research Institute, which is being formed by Ian Shoemaker, former Sandia intern and assistant professor of physics at the University of South Dakota.

Lab News Notes

Editor's Note: Lab News seeks guest columnists with observations on life at the Labs or on science and technology in the news and in contemporary life. If you have a column (500-750 words) or an idea to submit, please contact Jim Danneskiold, the acting editor.

IONIC AND ICONIC — In a 1985 file photo, VanDevender explains the ion diodes of PBFA II to Adam Klein, counsel and chief staff member for the House Armed Services Committee.

(Photo from A History of Exceptional Service in the National Interest)

Exceptional service in the national interest

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Livermore, California 94550-0969
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Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

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Classified ads 505-844-4902

Published on alternate Fridays by Internal & Digital Communications Dept. 3651, MS 1468

Society of Women Engineers recognizes Jackie Chen with its highest honor

By Michael Padilla

Jackie Chen has been recognized with an Achievement Award from the Society of Women Engineers for her impact on the society and the engineering community. The award is the highest honor given by the society and recognizes outstanding technical contributions of at least 20 years in engineering.

The award also recognizes Jackie's continuing dedication to the society's mission. SWE highlights the impact and importance of women in engineering across the globe, leading by example and demonstrating that a career in engineering can be a fulfilling, rewarding pursuit for women of any background.

Jackie will accept the award at the society's annual conference, WE18, in Minneapolis, Minnesota, on Oct. 19, during the formal awards banquet.

"I am honored to be recognized by the Society of Women Engineers for my research on computational simulation of turbulent reacting flows with complex chemistry," said Jackie, who has spent her entire career working at Sandia's world-renowned Combustion Research Facility. "I appreciate the work that SWE continues to do to highlight the importance of STEM and the impact the society has on the future generation of women engineers."

Chris Shaddix, Jackie's manager, submitted the nomination for the award. Chris said Jackie has truly outstanding technical achievements, a prodigious technical publication record and extensive professional leadership activities in the engineering profession.

Jackie's research has led to a deep understanding of the complex interactions of fluid flow and chemistry in flames, as revealed by some of the largest computational simulations ever performed, using some of the world's largest supercomputers. She has been elected to the most prominent advisory panels in the nation associated with both combustion research and scientific computing research and will be inducted to the National Academy of Engineering in September. Jackie regularly gives plenary and keynote talks and has been interviewed many times by the news media and other public communications associated with these fields.

TOP HONOR — Jackie Chen, a distinguished member of the technical staff at Sandia, has received the 2018 Achievement Award from the Society of Women Engineers, the society's highest honor. (Photo by Randy Wong)

According to the Web of Science, Jackie has published more than 135 papers — mostly in top research journals. Her papers received more than 580 citations in 2017 alone.

Jackie's research has focused on elucidating the combined influence of chemical reactions and fluid flow on combustion processes. She has developed a unique computer code to calculate the properties of turbulent fluid flow and flames. The code scales effortlessly across the hundreds of thousands of processors present in modern supercomputers. Jackie has devoted her career to a type of calculation called direct numerical simulation, which is the most accurate approach possible for modeling flames and turbulent flows because it fully resolves all relevant spatial and temporal scales of the flow and its associated chemical reactions.

"The men and women recognized have broken boundaries in their careers and personal lives," said Penny Wirsing, president of SWE. "They are leaders paving the way to empower and inspire future women engineers across the globe."

Sandia *Exceptional service in the national interest* CaliforniaNews

Animal planet

Sandia/California is home to snakes and bunnies and birds, oh my!

By Michael Padilla
Photos courtesy of Robert Holland

STANDING PROUD — An immature red-tailed hawk perches outside of Building 911.

DON'T TREAD ON ME — A gopher snake curls up in a shady corner to escape the summer heat.

Robert Holland and his team are outside Building 915 on Sandia's California campus looking for a swarm of bees that were reported circling the plants and alarming passersby. Their mission: find the busy bees, figure out how to contain them and restore order to the campus.

The reported bees were never found. However, Robert said beekeepers had removed a previous swarm from the site. He added that the most important protection for bees is minimizing pesticide use.

Robert, known to some as Sandia/California's "animal wrangler," receives calls on a regular basis about the many animals on site. From snakes to squirrels to foxes, Robert is knowledgeable about and keen on the animals that reside on campus.

"The site is a habitat for a range of wildlife species, many of which nest, den or forage around various areas of the campus," Robert says. "It's important that we continue to be diligent in maintaining a safe distance from the wildlife that we share our open spaces with."

For most of Robert's 27-year career at Sandia, he has been associated with the California site's ecology program. His long-held interest in ecology was strengthened by several field ecology classes that he took while pursuing a bachelor's degree in biology.

NO RATTLES HERE — Robert Holland holds a gopher snake found near Biulding 912. Although they look like rattlesnakes from afar, gopher snakes are not poisonous.

Robert's primary advice to the workforce is never to attempt to touch or capture wildlife because they can carry dangerous diseases. He also warns never to feed wildlife, including birds, ground squirrels and feral cats. Finally, he asks that workforce members close unattended storage spaces and equipment rooms and dispose of trash and food refuse in wildlife-proof bins.

Many of the animals are federally protected species, and Sandia corporate policy ESH100.2.ENV.2 prohibits trying to capture, touch, feed or approach wildlife.

Anyone who has wildlife problems (snakes, squirrels, turkeys, etc.) at the California site should call Robert at 925-294-3755 or the ES&H hotline at 925-294-ESAH. For pest issues (mice, ants, etc.), contact Maintenance at 925-294-6400.

BIRDS OF A FEATHER — Vultures, geese and barn owls are just a few of the many species of birds that can be found on Sandia's California campus and the surrounding areas.

Soot formation

(Continued from page 1)

The work was funded by DOE's Office of Science.

"The work represents an enormous scientific success as a result of years of support for focused, systematic work on developing a fundamental understanding of high-temperature hydrocarbon chemistry," Hope said.

Soot formation examined

Soot is formed during the combustion of hydrocarbon fuels, such as oil, natural gas and wood. Although it has detrimental health and environmental effects, soot is extremely important to many industrial processes such as boiler performance, glass production and carbon-black generation for rubber-product reinforcement and pigments.

Despite the ubiquity and importance of soot, the basic chemistry explaining why the molecules in a flame stick together at high temperatures and form particles has remained a scientific puzzle until now, Hope said.

In its final form, soot is a solid very similar to graphite, but it is initially formed from gaseous hydrocarbons. Experimental evidence indicates that it transitions from a gas to a liquid before it becomes a solid. Scientists have been trying for decades to explain that transition.

"Most people are familiar with how the gas phase of water — water vapor — condenses into droplets when it cools. Cooling it further will turn it into ice, the solid phase of water. Soot is different," Hope said.

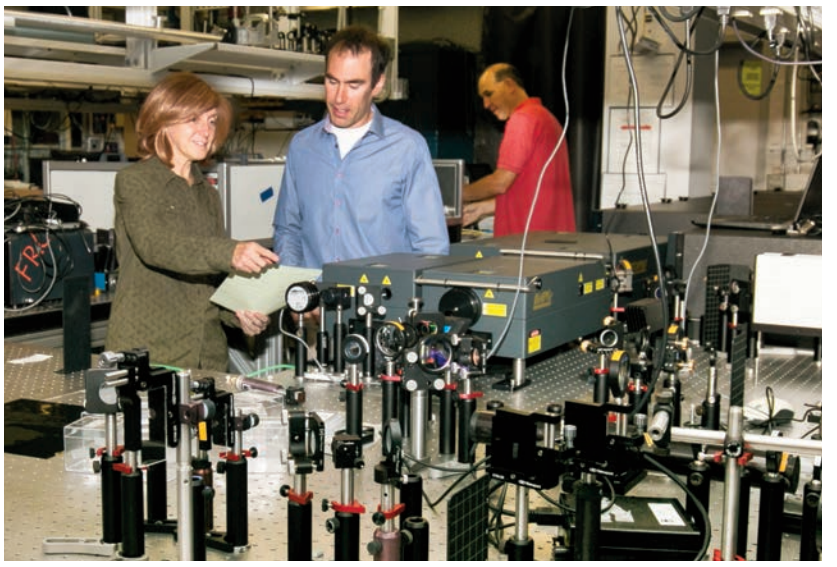
Soot particles are formed when gaseous molecules are heated to high temperatures, and they don't easily turn back to gaseous molecules the way water droplets do when they are heated up. Strong chemical bonds hold soot particles together. "Making soot is more like baking a cake than it is like condensing water. Heating liquid cake batter to high temperatures turns it into a stable solid form," Hope said.

Scientists have long suspected that chemical bonds must be formed to make soot. However, soot formation is fast, and researchers did not understand how the required chemical bonds could form so quickly. To make the problem even more difficult, researchers were not sure which gas-phase molecules were involved in producing soot.

"It's very difficult to make measurements in a flame," Hope said, "and without measurements of the participating molecular species, it's like trying to figure out how a cake is made without knowing the ingredients."

Radical species of flames studied

The key to soot formation, it turns out, is resonance-stabilized radicals, Olaf said. In general, molecules that are radicals have unpaired electrons they want to share, which makes them reactive. But, unlike most radicals, resonance-stabilized radicals have unpaired electrons that participate in other bonds in the molecule. Sharing electron density between the unpaired electrons and other bonds in the molecule makes these radicals more stable than other radicals, but nevertheless, they are more reactive than most of the other large molecules that form soot.



SOOT SLUETHS — Sandia researchers (left to right) Hope Michelsen, Olof Johansson and Paul Schrader have cracked the code to soot formation. (Photo by Brent Haglund)

Measurements conducted at the Advanced Light Source at the Lawrence Berkeley lab, a DOE Office of Science user facility, showed a sequence of resonance-stabilized radical species in all the flames studied. Hope said other researchers had seen the radicals and thought they might be involved in soot formation, but there didn't seem to be enough of them to be the main driver.

"We figured out that these radicals can start a chain reaction," Hope said.

When the radicals react with other molecules, they can easily form new resonance-stabilized radicals. In the process, they react with other gaseous hydrocarbons and keep growing, regenerating radicals as part of the growing particle.

Olaf said the researchers performed calculations to demonstrate that the reaction process should happen quickly.

Hope added, "It's really pretty simple. Well…once you know the answer. The chemical mechanism is relevant to a lot of high-temperature processes, including the formation of interstellar-dust particles, which permeate our galaxy. We are very excited about having unlocked the mystery of soot formation, the creation of carbon particles that are currently overwhelming some parts of the world as a result of forest fires, and that can have such a devastating effect on human health."

Massachusetts Institute of Technology Professor William Green said it has long been speculated that pathways involving resonance-stabilized radicals might be important in polycyclic aromatic hydrocarbon (PAH) and soot formation, since the known reactions are not fast enough to explain the rapid formation of soot.

"Indeed a few specific reactions of resonantly stabilized radicals leading to PAH are known, but until now, no one has presented a convincing general mechanism supported by experimental observations," Green said.

"I look forward to incorporating these newly discovered reaction pathways into a comprehensive PAH formation mechanism to determine the range of reaction conditions where these newly discovered pathways are important."

Truman Fellows

(Continued from page 1)

selection committee. "Those who go to academia become ambassadors for Sandia and frequently send their students to Sandia as interns, postdocs or staff members."

Of the 28 previous honorees, 17 subsequently joined the technical staff, and nine are still employed by Sandia. Applications for FY2020 fellowships will be accepted until Nov. 1, 2018.

Pauli Kehayias: ancient magnet hunter

Coming from the Harvard-Smithsonian Center for Astrophysics, Pauli has developed a new kind of delicate magnetic sensor for paleomagnetism, the study of ancient-Earth magnetic fields. Now he is going to apply the same principles to imaging microwave fields in microelectronics at Sandia.

"The committee was impressed with his relaxed mastery of solid-state physics and his combination of deep theoretical understanding with novel experiments," Cindy said.

He will be working with Peter Schwindt and Shanalyn Kemme in microsystems research.

How are you using diamonds as a new kind of sensor?

At Harvard, I'm using nitrogen vacancy centers in diamond to do magnetic microscopy of rock samples and meteorites. A nitrogen-vacancy center is one of many naturally occurring defects in diamond, in which a single nitrogen atom replaces a carbon next to a vacancy — a missing carbon atom. Other common defects may make diamonds yellow or blue. NV centers fluoresce when illuminated and are also paramagnetic, which is why we can use them to sense magnetic fields.

We can put NV centers very close (about five nanometers) to the diamond surface. Since you can put the NV centers as close as a few nanometers away from the magnetic sample you want to sense, the field is much stronger and the spatial resolution is better than with other methods. With micron spatial resolution, we're able to isolate the magnetic fields from the best magnetic recorders to make conclusions about the conditions of the early Earth and solar system.

How will you advance your work with sensors at Sandia?

I will continue developing better NV diamond microscopes and applying NV sensing to novel applications. This includes imaging electronics, materials and sensing in extreme environments. Paleomagnetism labs around the world are excited to adopt NV sensing for their experiments, and I hope to replicate this excitement for other areas of science and engineering.

Is it easy to adapt your technology from studying rocks to electronics?

With an NV magnetic imager, like for paleomagnetism, you apply a nominally uniform microwave field to the nitrogen vacancies to measure the magnetic field across a sample. For comparison, with an NV microwave imager you instead apply a nominally uniform magnetic field and measure the microwave field across a circuit. There's great similarity in the methods but for different applications. Fortunately, I can exploit many of the techniques from my previous work on rock magnetic imaging to imaging microwave fields.

What attracted you to Sandia?

I learned about the Truman Fellowship from my collaborator at the University of New Mexico, and visited the lab once before I applied. The environment is a great fit, and I hope that I can collaborate with Sandia experts on great interdisciplinary projects.

Thomas O'Connor: goopy polymer tamer

Thomas received his Ph.D. in physics from Johns Hopkins University last spring, where he distinguished himself by solving a decades-old riddle of why polyethylene is not as strong as it theoretically should be. He brings his wisdom about the material properties of polymers to Sandia to develop molecular models that improve industrial processes for additive manufacturing.

"Thomas impressed the committee with his strong commitment to and passion for national security and his exceptional ability to explain his complex work to non-experts," Cindy said.

He will work with nanostructure physics researchers Gary Grest, Mark Stevens and Ryan Wixom.

What's the problem you're attempting to solve for the plastics industry?

Polymer materials, or plastics, show up everywhere in modern life. Most applications require rapidly stretching and molding molten polymers in the liquid state. However, controlling the flow of polymers is very challenging because they are complex fluids. A common example of a complex fluid is ketchup. It resists flow while sitting still and will stay inside its bottle even if you turn it upside down. However, if you shake or tap the bottle, it will start to flow, sometimes much faster than you want! Polymer fluids can exhibit similar and often more complicated behaviors.

POLYMER TAMER — Thomas O'Connor has been invited to Sandia as a Truman Fellow to complete his research proposal, "Modeling the nonlinear rheology of additive manufacturing." (Photo courtesy of Thomas O'Connor)

Understanding how to predict or engineer these properties is very important for designing effective industrial processing methods. The same frustration you might face trying to get the right amount of ketchup onto a burger also plagues manufacturers trying to control the deformation and flow of polymers.

Where does your modeling expertise fit in?

My expertise is in modeling polymer materials and liquids at the molecular scale and using this information to develop and improve models for fluid flow at larger scales. We still have many important and unanswered questions about how polymers behave at the molecular scale, particularly when they are mixed with additives like nanoparticles or solvents.

Your emphasis at Sandia is additive manufacturing. What drew you to that?

The emergence of additive manufacturing is a fortuitous event for a polymer physicist like me. AM is an opportunity for me to apply my expertise to progress our basic understanding of polymer fluids, as well as serve the strategic interests of the U.S. government. It is also exciting to work on the science of a transformative technology like AM, as it is rapidly expanding and capturing the public interest.

How does working at Sandia fit into your family tradition of public service?

Both my parents, my grandparents and my uncle have all served as U.S. Navy officers. My father and uncle are still active duty.

As a physicist doing basic research, I was attracted to Sandia because of its reputation for valuing research and engaging with the academic community. I think maintaining this connection is strategically essential to ensure Sandia keeps pace with cutting edge techniques and can achieve research goals as efficiently as possible.

The Truman Fellowship is a real privilege, and I am grateful for the opportunity to use my expertise to both strengthen Sandia's external relationships and progress DOE's research agenda.

Sandia hosts Albuquerque's first CyberPatriot Advanced CyberCamp

By Troy Rummler
Photos by Amy Tapia

About 20 high school and middle school students came to Sandia recently for Albuquerque's first CyberPatriot Advanced CyberCamp, a weeklong cybersecurity workshop supporting the Air Force Association's CyberPatriot program. The workshop taught students advanced security concepts and prepared them for an upcoming competition season this fall.

Twelve Sandia volunteers from Albuquerque and Livermore pitched in as coordinators, teachers and support staff. Some also mentor CyberPatriot teams throughout the school year. Most students came from Albuquerque schools, though a few came from Los Lunas and Moriarty.

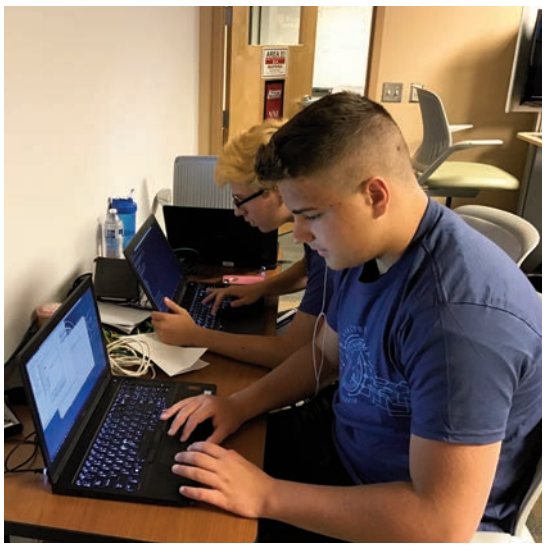
Co-coordinators Ted Lapina and Troy Stevens, both high school mentors, say they enjoy demonstrating general cybersecurity principles for students, but Sandia specialists served an indispensable role teaching niche topics.

"The participation of Sandia volunteers from several different organizations made this camp a unique opportunity for the students," Ted said. "It isn't every day that camp participants get to learn cybersecurity directly from the best in the profession."

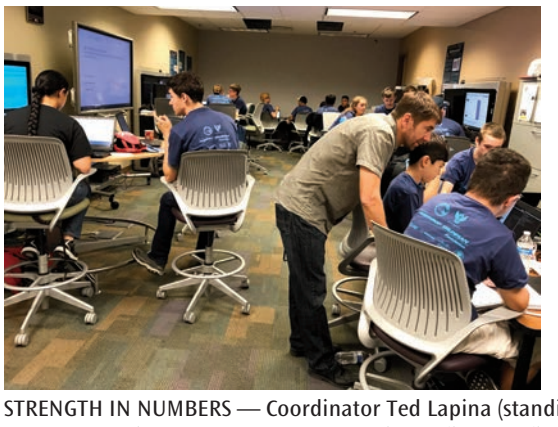
CyberPatriot organizes regular competitions in which students find and fix vulnerabilities in mock systems and networks, doing everything from creating secure password rules to finding malicious software. Teams begin facing off against other local and regional teams in November and can advance to a national competition in April. One school with Sandia mentors, La Cueva High School, has competed nationally.

CyberCamp attendees practiced their skills in small teams, using shared systems, and presented what they learned to their peers. Each morning, they also discussed a current issue in cybersecurity, such as vulnerabilities in biometrics and "internet of things" devices. The camp culminated in its own competition day.

Sandia employees interested in volunteering as cybersecurity mentors should contact Ted Lapina at tslapin@sandia.gov.



ADVANCED SKILLS — Cybercamp was held at the Cyber Engineering Research Laboratory located in the Sandia Science and Technology Park in Albuquerque.



STRENGTH IN NUMBERS — Coordinator Ted Lapina (standing) and Sandia volunteers mentored students during Albuquerque's first CyberPatriot Advanced CyberCamp. The students worked in small groups, collaborating to find and fix system vulnerabilities.

Strongest of the strong

Tiffany Tafoya wins regional strongman games and places third nationally

By Kristen Meub
Photos by James Ferree

Tiffany Tafoya, a Sandia missile defense technologist, deadlifts cars and carries around giant heavy stones in her free time. She's also really good at it.

Tiffany trains in strongman, a weightlifting-based sport that involves physical and mental strength, speed and endurance. Her passion for the sport has led her to win her division at the Rio Grande Celtic Strongman Games the last two years and place third at the 2018 U.S. Strongman Nationals this summer.

"It was great; it was a battle," Tiffany said, when asked about the national competition.

The word "battle" could also be used to describe her journey to this point. Last June she was diagnosed with rhabdomyolysis, a condition that releases a damaging protein into the bloodstream and causes muscles to rupture and tear.

KETTLEBELL TOSS — Tiffany tossed two 18-pound kettlebells and two 25-pound kettlebells over 10 feet behind her and took first place in this event at the Rio Grande Celtic Strongman Games.

"I was in the hospital for five days," Tiffany said. "It was pretty scary. It attacked my upper back. The doctors told me I would never be able to work out again, and that I should just find something else, another hobby."

Just before her hospitalization, Tiffany won the lightweight division of the 2017 Rio Grande Celtic Strongman Games, and then did an intense CrossFit workout. She said that those events, back to back, left her dehydrated, which led to the rhabdomyolysis.

"I'm just really stubborn, and basically when I left the hospital, I went straight to my home gym and tried to do a pull-up," Tiffany says. "I couldn't even budge, and pull-ups were my strong suit. It was devastating to hear the doctor say I wouldn't be able to work out, and then to go home and think, 'Maybe she's right'."

Tiffany was determined to get back into working out, so she met with different doctors, one of whom suggested she start practicing yoga. She also learned more about rhabdomyolysis and how to avoid it. She gave up CrossFit and focused on strongman training, which she describes as "lifting heavy weights for a short amount of time instead of lifting semi-heavy weights for long durations, like in CrossFit."

"I listened to my body after getting rhabdo," Tiffany says. "The doctors didn't know the faith I had in myself, and with God, and the heart that I had to get back into it. I was able to push through and recover my strength."

After about eight months of training, Tiffany went on to win the 2018 Rio Grande Celtic Strongman Games and qualify for nationals. Each strongman competition can have a different mix of events, which provides fresh challenges for the competitors. The Celtic games included a log clean and press, an 18-inch deadlift, a kettlebell toss, a farmer's carry and a sandbag carry.

"There weren't enough lightweight women registered, so they ended up combining our classes," Tiffany said. "So I was competing with girls weighing 165 pounds, while I weighed about 131. It was pretty intense, but it was fun."

At Nationals, Tiffany had to do 80-pound circus dumbbell repetitions, a car dead lift (a Chevy Cruze), an arm-over-arm car pull, 440-pound tire flips followed by a 500-plus-pound sled pull and lift a series of atlas stones (160, 190, 210 and 225 pounds) into a 50-inch tow truck bed. Her third-place finish qualified her to compete in the U.S. Strongman Pro-Women's World competition in October in Memphis, Tennessee.

FIRST PLACE — Tiffany Tafoya took first place in her division at the strongman competition that was part of the 2018 Rio Grande Celtic Strongman Games and placed third in the 2018 U.S. Strongman Nationals this summer.

"The stuff we do is insane, but my body has really been taking to it," Tiffany said. "I'm stronger now than I was before getting smart, and I train smart."

Tiffany says her ultimate goals are to earn her professional strongman card, which is something she can achieve by placing in the top three at the upcoming world competition, and to someday compete in a strongman Arnold competition.

"It's a way of saying that you are a professional athlete, that you've worked hard and earned that card," Tiffany said.

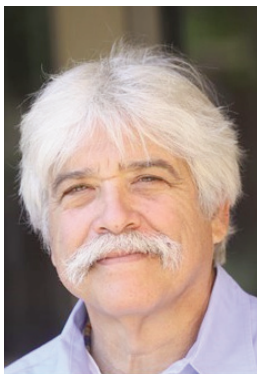
Tiffany hopes she can also encourage other women to try strength training.

"You never know how strong you are until you try. You'll be amazed at how strong you really are."

FARMER'S CARRY — Tiffany carried 145 pounds in each hand 155 feet in 60 seconds.

Mileposts

New Mexico photos by Michelle Fleming
California photos by Randy Wong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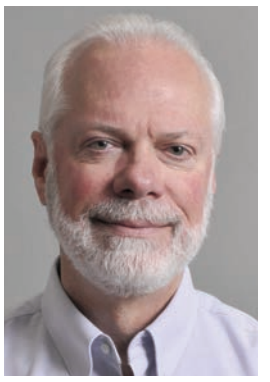
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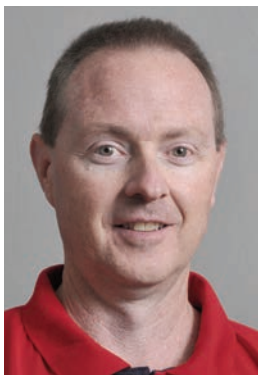
Charles Little 35


Cynthia Nelson 35


Allen Robinson 35


Roger Ten Clay 35


Robert K. Brown 30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Tom Klitsner 30


Courtenay Vaughan 30


Yvonne Baros 25


Carla Busick 25


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Bill Moffatt 25


Michael Pasik 25

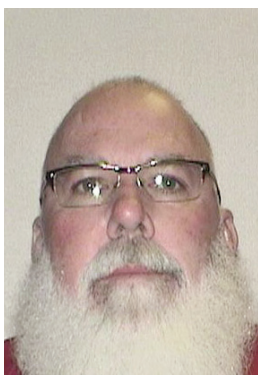

Evelyn Serna 25


Tony Brock 20


Lynnwood Dukes 20


Art Fischer 20


Gregory Guidarelli 20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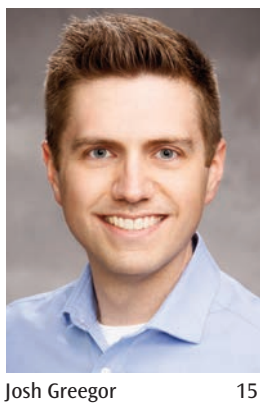
Ken Struve 20


R.A. Williams 20


Woody Woodstra 20


Stephen Zenker 20


James Dykes 15


Josh Greegor 15


Kristi Hickman 15


David King 15


Lawrence Monroe 15


Eric Montoya 15


Michael Pooler 15


Shane Ramotowski 15


Bud Siple 15


Matthew Snitchler 15


Judy Spomer 15

Recent Retirees


Dean Manning 40

SANDIA CLASSIFIED ADS

MISCELLANEOUS

SOFA, 3-seat, electric, contemporary brown, faux leather, very good condition, $300 OBO; massage chair, Brookstone uAstro2, full body, heat, like new, $2,250 OBO. Clem, 505-379-0475.

LAMINATE FLOORING, ~250-300, medium colored, with under lament, you pick up, free. Ward, 505-292-1618.

GENERATOR, Champion Power Inverter, 3100-W, used twice for music equipment, $700. Willmas, 505-281-9124.

SEWING MACHINE, Brother Innov-IS, new-in-box, retail $700, asking $500. Stephens, 505-292-6515.

SALE, Sept. 14/15, 9 a.m.-4 p.m., 11705 Mountain Rd. NE, telestep-ladder, 5th wheel stabilizer, tote, chocks, stove, heaters, lots more. Self, 505-296-4137.

FLOOR JACKS, 2, 54"-100", max ht. cap 5,600 lbs., min. ht. cap 8,438 lbs., both $60, https://tinyurl.com/y9z7esm9. Thompson, 505-358-2298.

ARTIST'S EASEL, oak, w/clamp-on Ott-Lite, $50 firm. Hamilton, 505-379-0339.

SOLITAIRE DIAMOND RING, Blue Nile, radiant cut, 0.7 ct., kite set, platinum band, $750 OBO. Craven, juliamcraven@gmail.com.

FURNITURE: 6-pc. bdr. set, $325; home office desk, solid wood, L-shaped executive, $350; plaid sofa & love seat, $250. Pfeifle, 505-856-6775.

RUMMAGE SALE, Sat. Sept. 15, 7 a.m.-2 p.m., 811 S. Camino del Pueblo, Bernalillo, benefits Christian Motorcyclists Assoc. Walker, 505-259-0937 or bikerz4christ@msn.com.

COLLECTIBLE 1999 CHEVRON CAR, Casey Coupe No. 18, yellow w/eyes, pristine condition, $8. Wagner, 505-504-8783.

PARAKEETS, 2, male, w/cages & accessories, need finger training, pretty birds, empty nesters want to find them new home, $50. Willis, 505-286-1937.

GENERATOR, Honda EU 7000 IS EFI, 30-amp, electric start, like new, $3,900. Moreno, 505-238-0494.

TRANSPORTATION

'11 TOYOTA SIENNA LE, V6, AT, 105K miles, $10,995. Jones, 505-839-4180.

'18 FORD F-150 XLT, 4x4, 5.0 L, V8, AT, crew cab, 5.5-ft. short bed, black, gray cloth interior, alloys, bed liner, 312 miles, truck is brand new, $32,000. Dwyer, 505-249-6935.

'08 LEXUS IS250, RWD, 6-spd. manual, 89K miles, new tires, good condition, $9,950 OBO. Chavez, 505-385-2574.

'15 SUBARU LEGACY LIMITED, 1 owner, 32K miles, $16,000. Clayton, 505-221-4918.

'08 TOYOTA TACOMA, TRD off road & tow pkg., double cab, 70K miles, outstanding, $20,000. Washburn, 505-275-3751.

'93 GEO METRO DIY EV CONVERSION, comes w/original gas motor, search Craigslist for listing, $2,000. Holtey, 505-620-3051.

RECREATION

'07 SUNDANCE 5TH WHEEL TRAILER, 33-ft., 3 slides, all season, call for photos, $9,500. Garcia, 505-699-6844.

ROAD BIKE, Jamis Venture Corp, 2x9, Tiagra, 48 cm, gator skins, Xero Lite wheels, aluminum, carbon post, $350. Barry, 505-220-6783.

'17 AVENGER TRAVEL TRAILER, 17-ft., used 1 time, stored inside, full bath, paid $14,000, asking $11,000. Hapka, 505-220-9114.

MOUNTAIN BIKE, Kona HeiHei Scandium, full-suspension, medium frame, 26-in. wheels, all high-end components, beautiful, pristine, $875 OBO. Goodson, 505-407-1688.

REAL ESTATE

4-BDR. HOME, 2-1/2 baths, 2,263-sq. ft., 2-story, near Indian School & Tramway, great condition, $250,000. Landin, 651-338-0760.

3-BDR. CONDO, 2-1/2 baths, 2,150-sq. ft., Four Hills, recently updated, 432 Pinon Creek Rd. SE, $219,900. Carlisle, 505-480-2478.

2-BDR. CONDO, 1-1/2 baths, 935-sq. ft., 8333 Comanche 3C, new carpet, ready to move in. McCaughey, 505- 821-3854.

2-BDR. TOWNHOUSE, 1-3/4 baths, 1,100-sq. ft., NE Heights, across from Tanoan (Eubank & Academy), $165,000. Fluckey, 505-803-5012.

3-BDR. LOG HOME, 3 baths, 1,826-sq. ft., 39 Terrero Ranch Rd., Terrero, NM, 1 hr 45 min. from Albuquerque, photos on Zillow, only 10% down, $324,900. Garcia, 505-280-8680.

WANTED

HARDWOOD LUMBER, for woodworking. Burgett, 505-205-5070.

VENDORS/SHOPPERS, annual Canterbury Craft Fair, Sat., Sept. 29, 425 University Blvd. NE, 87106. Hughes, 505-296-8940 or Beard, 505-828-0673.

VOLUNTEERS, to help Fabulous Felines w/kittens, http://fabulousfelines.org. Stubblefield, 505-263-3468, fabulousfelines@comcast.net.

MEXICAN AND/OR U.S. COIN COLLECTIONS, for sale. Keiss, 505-417-0035.

FLC Awards

(Continued from page 1)

These include:

• Business development specialist Jason Martinez, for strengthening the Labs' Cooperative Research and Development Agreement strategy and significantly increasing the CRADA portfolio three years in a row.

• The Labs' 25-year partnership with The Goodyear Tire & Rubber Co., which has produced many successful projects and advances for the tire industry and the Labs.

• Partnership on a software toolkit for emergency planners and first responders.

• Advances in the science of scintillators — objects that detect nuclear threats — through the development of organic glass.

The FLC Awards are considered some of the most prestigious honors in technology transfer.

"The FLC Awards provide feedback to Sandia about the value of our technology partnerships program," said senior manager Mary Monson. "Through partnerships, we support the Labs' missions, improve national security and benefit U.S. industry."

Sandia winners were recognized at an awards ceremony Aug. 29 in Oklahoma City.

CRADA STRATEGIST — Business development specialist Jason Martinez developed and implemented a strategy that strengthened Sandia's CRADA portfolio. (Photo by Lonnie Anderson)

Strategy development leads to significant CRADA growth

Not long after he became a CRADA specialist at Sandia, Jason developed and implemented the Labs' first CRADA strategy in its 36-year history of CRADAs. Jason won a Technology Transfer Professional of the Year award for the strategy's impact in the Mid-Continent Region.

Jason said soon after he started working at Sandia in 2013, he met 15 engineers at a poster session who worked on various new technologies, and none of them had heard of CRADAs.

"There was a need to augment awareness that CRADAs can take place between Sandia and outside companies," he said. "Sandia has 70 years of history and billions of dollars' worth of taxpayer-funded research and development. We can use some of that research to benefit the economy with tech transfer."

The strategy encourages proactive engagement with researchers and managers to better educate them about CRADAs. Martinez's efforts with the CRADA strategy led to significant growth of Sandia's CRADA portfolio. In 2017, 41 CRADAs were established between Sandia and private companies or universities as compared to about 20 per year prior to 2013.

"What I really enjoy seeing now is the excitement and enthusiasm from engineers who want to work with other companies using the CRADA mechanism," Jason said.

Strong decades-long partnership continues

Sandia won a Mid-Continent Regional Partnership Award for past achievements and a continued partnership with Goodyear. The Labs and the tire company signed a CRADA in 1993, when technology transfer from national labs was in its earliest stages. The collaboration, still strong today, allows Sandia to enhance software modeling capabilities while simultaneously addressing Goodyear's challenges.

TOP TEAM — Computer scientists (left to right) Vicki Porter, Byron Hanks and Antonio Recuero from Sandia and Mohammed Sobhanie of The Goodyear Tire & Rubber Co. study images of tire technology. (Photo by Jennifer Plante)

The partners are working on several strategic projects. One supports virtual tire models to accurately predict tire performance before the tires are built, which enables Goodyear to submit tire models to car manufactures early in the design cycle. Another active project involves modeling tire materials for the best combination of material properties. Sandia also advanced simulating the flow of turbulent air around rotating wheels, enabling noise modeling of rotating tires.

Ted Blacker, Sandia's program manager for the Goodyear CRADA, explained why the partnership has been successful.

"We focus on strategic technical challenges where advanced technology from both sides can change the future," he said. "Almost without fail, the new capabilities they commission us to develop — for example, model rotating, twisting and deforming tires — help us with simulations in our national security work."

Goodyear's engineers design every tire with Sandia-developed tools, which are run thousands of times a day, Blacker said.

New capabilities emerge for emergency planning

To improve emergency planning, exercises and protocols, Sandia, the California Fire and Rescue Training Authority (CFRTA) and the Sacramento Metropolitan Fire District collaborated to deploy SUMMIT, or the Standard Unified Modeling, Mapping and Integration Toolkit. The software, initially developed through funding from the Department of Homeland Security, helps users create scientific models and simulations. This collaboration won a Far West Region Outstanding Partnership Award.

"Sandia and the CFRTA's strong relationship over the past four years has yielded many benefits," said Sandia manager Nerayo Teclemariam. "CFRTA has gained early access to emerging technologies that can enhance preparedness across the state, and Sandia has gained operational partners that help guide research and development with their real-world experiences."

Emergency planners need to understand consequences of disasters and the impacts of response options for natural risks such as earthquakes and wildfires, and man-made risks such as improvised explosive devices. Emergency responders also require real-time and projected event details such as infrastructure damage, possible numbers of casualties or displaced citizens.

Other technologies used by the California authority track resources and maintain situational awareness of current activities such as current weather or location and size of a fire. The modeling feature in SUMMIT provides forecasts so users can project how natural and unnatural disasters could spread, and what critical infrastructure might be affected.

SUMMIT was used in an exercise called Decisions Matter that simulated a terrorist attack involving an improvised explosive device planted next to a chlorine tanker. The explosion caused a hazardous chlorine plume, and SUMMIT helped exercise participants — including hazardous materials first responders and public health officials — calculate population health impacts and medical surge requirements, as well as analyze evacuation routes and timing issues.

"It's been a positive, mutually beneficial experience to have a national lab deploy technologies with local responders," said Sandia researcher Lynn Yang. "First responders are very well trained in day-to-day events; we try to help plan for the catastrophic incidents that are rarely encountered but that potentially have very large consequences."

Organic glass nuclear detectors on the horizon

It could soon be more difficult to smuggle nuclear materials through U.S. ports and borders using organic glass scintillators. The small, handheld detectors engineered by a Sandia team and California-based XIA, LLC, won the Far West Region Outstanding Technology Development Award.

Sandia's organic glass scintillator has been engineered for high detection efficiency of radioactive material without high production costs. Organic scintillators produce light in response to the presence of nuclear materials. Depending on the amount of light produced and the speed with which the light appears, the source can be identified.

The simplicity and low cost of manufacturing could allow for widespread use. Currently, threat detection scintillators are either made from expensive materials or plastics that have limited ability and cause frequent false alarms.

Due to its advantages over existing scintillator products, XIA is integrating Sandia's organic glass scintillator into detectors for real-world applications. The partners have been working together since 2017.

"I'm glad that we were able to meet our goal to make something higher performing and more affordable than the options that were out there, and we were able to use out-of-the-box thinking to get there," said Joey Carlson, a Sandia materials scientist who works on the scintillators.

The team is now researching the possibility of blending other materials with the organic glass scintillators to improve detection, which could lead to broader applications.

‘A win-win for everybody’

NM schools receive 1,170 donated Sandia computers, accessories

PC PREP — Supply Chain team lead Michael Somuk prepares for Sandia’s annual K-12 Computer Donation Event. More than 40 New Mexico schools participated this year.

By Manette Newbold Fisher
Photos by Randy Montoya

Students from more than 40 New Mexico schools benefitted from Sandia’s annual K-12 Computer Donation Event, where more than 1,100 computers and related accessories were distributed.

Representatives from schools around the state gathered at Reapplication last month, some driving trucks and trailers for up to four hours to pick up the donations. They collected desktop computers, laptops and iPads for students, along with printers, power cords, keyboards, mice, headphones, monitors and speakers. This year, Sandia distributed 842 desktops, 327 laptops, 46 iPads and nearly $100,000 in peripherals and accessories.

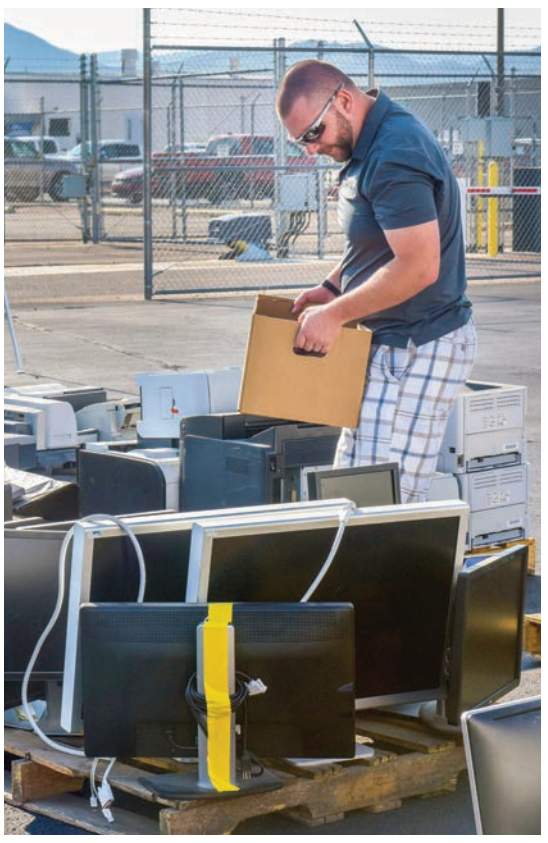
Michael Somuk, who leads the supply chain team that put together the project, said all equipment was in good condition following use by employees for day-to-day work and special projects. Once the equipment reaches the end of its useful life at Sandia and is no longer needed, it’s donated to schools.

Ben Potts, director of technology for Silver Consolidated Schools, said the annual donations benefit nine schools in his district. Before the Silver City district started participating five years ago, students used outdated equipment, and the district was behind in preparing for the statewide digital rollover for standardized testing. Potts said every computer lab in the district now uses equipment from Sandia, including a new technology lab at the high school.

TECHNOLOGY TRANSFER — Reapplication team employee Marcus Barela (left) records property information prior to its release from Sandia. Bernadette Bazen (center) and Semiramis Novak, also on the Reapplication team, help load desktop computers into a vehicle for one of the schools.

“We’ve been able to add labs, and for the most part, teachers are able to obtain as many computers, laptops and iPads as they need,” Potts said, adding that as older equipment is rotated out, teachers continue to use it to teach students about the insides of computers or use parts to teach robotics, further extending the useful life of the computers.

“It’s a win-win for everybody because the schools get computers and equipment in good shape,” said Michael. “In New Mexico, that is extremely valuable because some school districts have extremely tight budgets. We’ve had schools come to us and say, if it wasn’t for this program they wouldn’t have any information technology resources.”



COMPUTERS FOR KIDS — A school representative checks out a pallet of monitors. In addition to computers, monitors and printers, schools were able to choose what they needed from a selection of keyboards, cords, mice and other related accessories.

SCREEN TIME — Keith Legoza of El Camino Real Academy in Albuquerque was one of more than 40 school representatives who collected monitors and printers during the K-12 Computer Donation Event held at Reapplication. Sandia’s supply chain team works with schools to determine their needs ahead of the event.